Principles and practice of thoracic anaesthesia

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Most lung resections are carried out for the surgical treatment of primary malignant tumours (Figure 1). 80% of primary lung tumours are inoperable at presentation, therefore only about 3000 of these operations are performed annually in the UK. Mortality for pulmonary resection remains relatively high at 5% for pneumonectomy and 2.9% for lobectomy, and therefore preoperative assessment of these patients (see *Anaesthesia and Intensive Care Medicine* **6:11:** 386) is important.

The appropriate management of anaesthesia and one-lung ventilation facilitates surgery and is likely to improve outcome. Recently there has been an increase in the number of thoracic procedures carried out using video-assisted thoracic surgery (VATS). These procedures almost all require one-lung ventilation at times and the observed physiological changes and principles of management are similar to those during pulmonary resection.

Thoracotomy and pulmonary surgery

Positioning the patient

Most pulmonary resections are undertaken with the patient in a lateral position. Following induction of anaesthesia, intubation, insertion of intravascular lines and confirmation of the side of surgery, the patient is turned into the lateral position. Several devices can be used to stabilize the patient on the operating table (Figure 2). The lower shoulder is pulled through anteriorly, allowing the flexed lower arm to be tucked under the pillow supporting the head. The upper arm is extended and placed over the head, taking care not to stretch the brachial plexus. Some surgeons who use a more anterior muscle-sparing incision, prefer to place the upper arm in a padded arm support attached to the head of the operating table.

Stability of the pelvis is achieved by flexing the lower leg at the hip and knee while the upper leg, padded with a pillow, is kept relatively straight. Further stability may be achieved with chest and pelvic supports. Once the patient is positioned and all vulnerable areas padded, a warm-air convective heating blanket is applied to minimize heat loss during surgery.

Thoracic surgical results from 47 UK centres (1999–2000)

	Numbers	Deaths
Lung resection for primary malignant tumours		
Pneumonectomy	779	39 (5.0%)
Lobectomy/bilobectomy	2208	63 (2.9%)
Video-assisted thoracoscopic surgery (VATS) for pulmonary/ pleural disease		
Lung biopsy	506	6 (1.2%)
Bullae	56	2 (3.6%)
Lung volume reduction surgery (unilateral)	50	3 (6.0%)
Lung volume reduction surgery (bilateral)	15	1 (6.7%)
Pneumothorax (various procedures)	735	6 (0.8%)
Pleural biopsy	499	5 (1.0%)
Pleural biopsy and chemical pleurodesis	932	18 (1.9%)
Pleurectomy	84	2 (2.4%)
Pleurectomy and drainage of empyema	154	4 (2.6%)

Adapted from: The database of The Society of Cardiothoracic Surgeons of Great Britain and Ireland

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Physiological consequences: in the awake patient there is little or no additional ventilation–perfusion mismatch in the lateral position. An increase in perfusion to the lower lung, caused by the effect of gravity on the low pressure pulmonary circulation, is matched by increased ventilation because this lung is on the steep part of the compliance curve (Figure 3). During anaesthesia the situation changes. In the spontaneously breathing patient there is a reduction in inspiratory muscle tone (particularly the diaphragm) and a decrease in the volume of both lungs with a reduction in functional residual capacity (FRC). The non-dependent upper lung therefore moves to the steeper part of the compliance curve and receives more ventilation. Paralysis and intermittent positive pressure ventilation (IPPV) are used during thoracotomy to overcome the problems of the open pneumothorax created by surgery. The compliance of the non-dependent lung is further increased in this situation. In practice, it is usual selectively to ventilate the lower lung (one-lung ventilation; OLV) at this point and allow the upper lung to collapse. This eliminates the preferential ventilation and facilitates surgical access but causes ventilation–perfusion mismatch.

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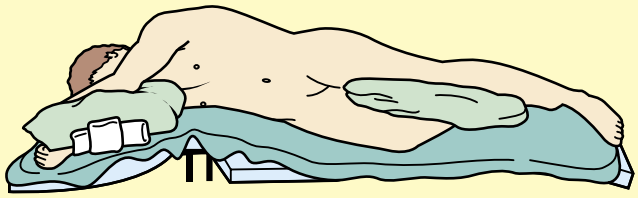
The lateral thoracotomy position

The patient is stabilized by a comfortable mattress. Note the 'bridge' raised in the operating table, directly below the chest, to aid surgical access



From: J W W Gothard. *Anaesthesia for thoracic surgery.* Oxford: Blackwell Scientific Publications, 1992

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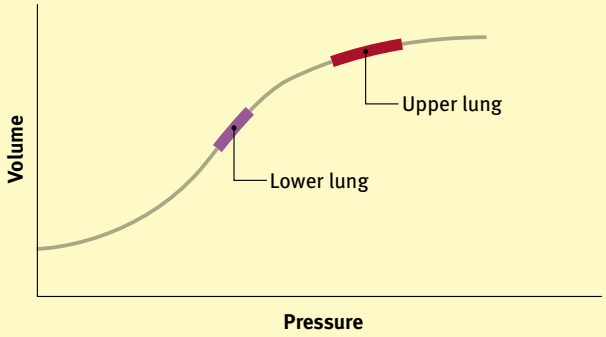
Anaesthesia

The principles of anaesthesia for thoracic surgery are the same as those for any major surgery. Anaesthesia is usually induced intravenously. The choice of agent is seldom important. Patients presenting for lung resection are unlikely to have a co-existing airway problem and therefore a non-depolarizing neuromuscular blocking agent can be used to facilitate intubation and IPPV. A long-acting agent (e.g. pancuronium) is suitable for most operations but it is equally acceptable to use short-acting agents and give incremental doses as required. Special consideration must be given to patients with muscle weakness caused by myasthenia gravis or the myasthenic syndrome. Occasionally patients presenting for palliative VATS have an airway problem relating to tracheal or bronchial compression or an endobronchial tumour, but patients undergoing lung resection are more likely to present as a 'difficult intubation' on the basis of conventional criteria.

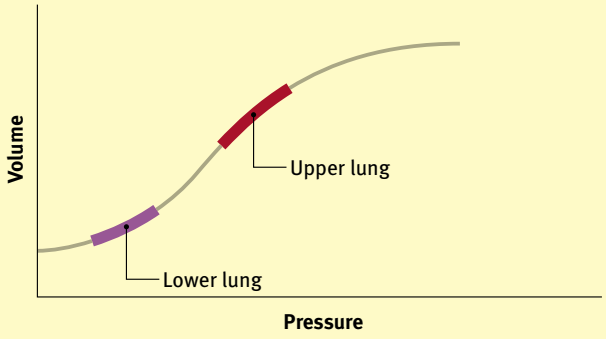
Anaesthesia can be maintained with volatile agents delivered in an air/oxygen gas mixture or an oxygen/nitrous oxide mix. Alternatively, anaesthesia can be maintained intravenously with propofol, possibly in combination with remifentanil.

Compliance curves for upper and lower lungs in the lateral position

Patient awake



Patient anaesthetized



From: Yentis S M, Hirsch N P, Smith G B, eds. *Anaesthesia and intensive care A–Z.* 2nd ed. Oxford: Butterworth-Heinemann, 2000

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Hypoxic pulmonary vasoconstriction (HPV)

HPV is a homeostatic mechanism whereby pulmonary blood flow is diverted away from hypoxic or collapsed areas of lung. It might be expected to improve oxygenation during OLV, but *in vitro* experiments have shown that volatile agents inhibit HPV though *in vivo* studies have failed to demonstrate gross inhibition. Although volatile agents depress HPV directly, they also enhance it by reducing cardiac output. Therefore, HPV response is apparently unchanged in the presence of volatile agents during thoracotomy and OLV. Handling the lung also reduces HPV.

Potent inhaled anaesthetic agents (e.g. isoflurane) are not contraindicated during OLV and may be desirable because of their bronchodilator properties and ease of use. Significant inhibition of HPV is more likely with halothane, which should be avoided.

Intravenous agents (e.g. propofol) do not inhibit HPV and should improve arterial oxygenation during OLV. Evidence in the literature supports this contention, but it is inconclusive. Therefore, in patients with poor arterial oxygenation during OLV, it might be worth changing to a total intravenous technique.

Analgesia

If opioid drugs are to be used postoperatively it is logical to use the same drugs intraoperatively. If epidural analgesia is to be used postoperatively it should be established before surgery.

Monitoring

Monitoring and vascular access for major pulmonary surgery should be comprehensive (Figure 4). Pulmonary artery catheters can be placed in the lung contralateral to surgery only if radiological screening facilities are available. This is unnecessary in routine clinical practice. Transoesophageal echocardiography is not used during routine thoracic surgery but it may be used in the management of high-risk patients in the future.

Ventilation

Endobronchial tubes or bronchial blockers are inserted immediately following induction of anaesthesia or after preliminary bronchoscopy. Use of these devices to achieve lung separation and collapse of the lung on the operative side is described on page 425.

Management of OLV: pulmonary blood flow continues to the upper lung during OLV, creating a true shunt where there is blood